Università di Genova | DIFI DIPARTIMENTO DI FISICA

PHD IN PHYSICS AND NANOSCIENCE – XXXIX CYCLE – FIRST YEAR REPORT

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Research activity

Blazars, active galactic nuclei characterised by relativistic jets pointing almost directly at the Earth, are one of the most energetic and poorly understood phenomena in the Universe. My PhD project focuses on the study of these enigmatic objects, both from a phenomenological point of view and through observations with the Euclid space telescope. Essentially, my research aims to optimise the resolution of the Euclid images and spectra with the main purpose of better distinguishing the relativistic blazar jet from the host galaxy. By analysing Euclid's systematics, it will be possible to obtain the high-precision photometric and spectroscopic measurements needed to better understand the physical mechanisms underlying these objects.

Euclid is an ESA space mission launched on July 1, 2023 dedicated to Fundamental Cosmology and Astrophysics. Euclid will operate for 6.5 years in orbit around the Lagrange point L2 of the Sun-Earth system, focusing on understanding the evolution and the composition of the Universe, shedding light on the nature of Dark Matter and Dark Energy. To achieve these goals Euclid relies on extremely high-precision measurements made with a telescope with a 1.2-meter aperture and two instruments, the Visible imager (VIS) and the Near-Infrared Spectro-Photometer (NISP). Euclid will collect high-quality images at optical and near-infrared wavelengths of about two billion galaxies and measure emission-line redshifts for tens of millions of galaxies, creating a large-scale 3D map of the structure of the universe.

To guarantee the success of the mission, precise instrument calibrations must be made for the telescope to perform reliably once it is in orbit. In this respect, the Euclid group consisting of INFN & University of Genova has committed to work in the Instrument Operation Team activities regarding the NISP instrument. During my master thesis, I participated in the Science Performance Verification 2 pre-launch exercise, validating the results of the calibrations of physical effects which may affect the pixel response of detectors used for the NISP Detection System (NI-DS) by generating background counts and distorting the measurement of the spectra of astrophysical sources. Specifically, I focused on a few phenomena, such as dark current, inter pixel capacitance, non-linearities of pixel responses and persistence, and was in charge of comparing their calibration products with the in-flight simulations, making sure that the requirements of the nominal ESA mission were met.

The first task of my PhD activity was to participate in the Commissioning, during which PV2 data-analysis pipelines will be repeated and comparisons with the measurements reported on the ground were performed. I compared the calibration and pre-launch simulation data with the on-the-fly data, analysing the performance relative to the dark current and the features at closed shutter, and I was involved in the analysis of the Raw Lines and Fine Guidance Sensor (FGS) to verify the Euclid pointing stability in first approximation.

In collaboration with S. Dusini (INFN Padova), in order to demonstrate that the Relative Pointing Error (RPE) recorded in the FGS TM is a real displacement of the telescope, I created an algorithm to

observe the residual instability of the telescope in the NISP engineering raw images recorded during the first months of Commissioning, and to read FGS telemetry. We demonstrated that the jitter recorded by NISP and FGS were compatible, and in the future it would be possible to use FGS telemetry to reduce the effect of the pointing instability on the PSF and improve NISP and VIS images a posteriori by correcting the FGS RPE. I presented the preliminary results of this work with a poster at the EC Rome 2024.

At the same time, with the Euclid group of Genova, I was involved in the creation of tools for health monitoring of the NISP instrument. In particular, I participated in the activities for the development of tools for Quick Look Analysis (QLA) and telemetry check and after the first release of the monitoring tools, I actively participated in the "test" shifts of the first months, and I am currently involved in the development of the NISP monitoring shifter manual and in the routine cycle shifts.

In addition to this work, I have started a new project with Tullia Sbarrato and Chiara Righi (INAF OABr) aimed at improving our knowledge of blazars. In particular, we are delving into the nature of host galaxies associated with blazars, with a primary focus on confirming or debunking the prevalent hypothesis suggesting their elliptical nature, that will ultimately help in studying their central black holes. BL Lacertae objects (a numerous blazar subclass) completely lack the broad emission lines typically used to derive the black hole mass, that is instead estimated by analysing the luminosity of the host galaxies. For this reason, it's crucial to provide a detailed characterization of the host galaxies.

To achieve this goal, we have begun a feasibility study. The first step was to write a code to simulate ideal spectra of BL Lacs in the near UV to mid-infrared range, varying the host between elliptical and spiral galaxies, the luminosity of the blazar jet, and the redshift. I then tested and adapted QSFit, a software for decomposing QSO spectra into all their components and emission lines, for the study of blazars. I calibrated QSFit on the synthetic spectra produced by my algorithm and identified some crucial parameters to distinguish when the software fit well the host galaxy in the spectrum and when not.

Attended courses:

I attended the following courses:

1. *Introduction to High-Energy Astrophysics*: PhD course by F. Tavecchio (INAF)
2. *Astronomical Instrumentation*: PhD course by L. Cabona (INAF)
3. *Astrofisica e Cosmologia Computazionale*: Master degree course by A. Veropalumbo (INAF) and M. Raveri (Unige).

I'll attend to a PhD school in place of a doctoral course:

- *INFN School SoUP 2024*: 14-18 October 2024, CEUB in Bertinoro (FC), with poster presentation.

Publications:

1. Euclid Collaboration: Y. Mellier et al, "**Euclid. I. Overview of the Euclid mission**", paper submitted as part of the A&A special issue "Euclid on Sky", 2024 (arXiv:2405.13491)
2. W. Gillard et al, "**Euclid Near Infrared Spectrometer and Photometer instrument NISP in space**", SPIE proceeding
3. F. Cogato et al, "**Euclid commissioning results: the Near Infrared Spectrometer and Photometer (NISP) signal detection chain**", SPIE proceeding
4. P. Battaglia et al, "**Euclid: The Near Infrared Spectrometer and Photometer (NISP) Instrument Operations**", SPIE proceeding

Conference presentations:

1. Participation at the Euclid Science Working Group for Galaxies and Active Galactic Nuclei Evolution (SWG-GAE) Workshop, 14-16 February 2024, Bologna.
2. Poster session at Euclid Consortium Annual Meeting – "**Can Euclid see better? Towards an improvement of instruments PSF with FGS telemetry**",17-21 June 2024, Rome.
3. Virtual poster session at EAS 2024 – "**Can Euclid see better? Towards an improvement of instruments PSF with FGS telemetry**",1-5 July 2024, Padova (remote attendance).
4. Participation at the From Darklight to Dark Matter: Understanding the Galaxy/Matter Connection to Measure the Universe, 16-17 September 2024, Sestri Levante (GE)
5. Abstract accepted for talk at XVth Italian meeting on Active Galactic Nuclei: from the present-day Universe to the Dark Ages – "**The ever elusive blazar host galaxies: a guide to their characterization**", 23-27 September 2024, Padova.